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This study aims to explore how people discuss natural disaster events on Twitter. In particular, it seeks to evaluate how frequently people are relating a single natural disaster event, Hurricane Isaias in 2020, to climate change. For this research, a content analysis of tweets was conducted and evaluated. Twitter data was collected from the Twitter API discussing Hurricane Isaias using specified event keywords. During data analysis, the tweets were thematically coded and some basic statistical analysis was performed. The study found that informational updates dominated the discourse until the storm weakened. As the storm weakened, informal discourse began to spike, with users anecdotally describing their experiences during the storm and the aftermath. In addition, nearly 3% of all tweets related the storm to climate change. The potential impact of this study is to help researchers, responders, and policymakers better understand how people are using Twitter during natural disaster events. This could identify room for improvement in disaster relief and recovery.

Headings:

Twitter

Social media

Natural disasters

Climate change

Content analysis

A CONTENT ANALYSIS OF NATURAL DISASTER DISCOURSE ON TWITTER

by
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Table of Contents

Introduction

Social media platforms have begun to shape how people receive and interact with news and communicate with one another. In particular, Twitter is a microblogging platform that allows users to compose short 140-character messages, called *tweets*, to post to the online Twitter platform. Users can follow one another asymmetrically. Users can also retweet or favorite another user's message. Hashtags are another Twitter convention. Hashtags have become a commonly used form of communication online about a specific trending topic. It allows users to filter tweets or join the conversation by adding the hashtag to their original tweet. Hashtags allow for fluid and filtered communication about a specific topic.

This study seeks to understand how people are using Twitter during the phases of a natural disaster event to communicate about the event. Twitter has a powerful potential during natural disaster events by providing a real-time mapping and event summarization to give a better understanding of the event unfolding. Twitter can also provide communication of emergency procedures, dangerous conditions, and access to resources. It can also be a way for Twitter users around the world to send their support to those affected by the particular disaster event, potentially providing a sense of community and emotional support. There have already been several studies on the accuracy and implications of Twitter in real-time event detection and summarization. However, this study seeks to explore tweets using a particular natural disaster keyword, Hurricane Isaias through content analysis, coding tweets, grouping common themes, and evaluating the

tweet sentiments to understand the ways users are using Twitter during these emergency events.

A unique aspect of this study is the particular interest in whether users associate a single isolated natural disaster event to the theory of anthropogenic climate change. Climate scientists have hypothesized that anthropogenic climate change can have impacts on both the frequency and intensity of natural disaster events. As the atmosphere changes, the climate is expected to experience more frequent and extreme hot and cold days. There is also the likelihood of more intense precipitation events or occurrence of droughts depending on the local context. Although it is hard to link a specific storm event to climate change, there is growing consensus that the occurrence of such events is rising. The 2020 hurricane storm season, which doesn't officially end until November 30th, is already record-breaking. It has tied the record for being the most active storm season since 2005, with twenty-eight named storms (Thompson, 2020). Twenty-four of these storms were the earliest of their storm number to develop (Thompson, 2020). Additionally, six hurricanes have hit the US this year, which tied 1886 and 1985 for the most hurricane landfalls in a single season (Thompson, 2020). More people are beginning to acknowledge these events as climate change related. Therefore, this study aims to understand whether Twitter users are associating a particular event to climate change.

Literature Review

Twitter and Content Analysis

Twitter was launched in 2006 with the purpose of allowing users to answer the question: “What are you doing?” (Honeycutt & Herring, 2009). However, a study done in the years immediately following Twitter’s launch found that nearly 60% of all tweets did not address this question (Honeycutt & Herring, 2009). Twitter instead began to evolve into a facilitator of conversation, where users are able to communicate and collaborate with one another. It also allows for information dissemination. Twitter uses hashtags, ‘#’, to group tweets and provide a streamlined way to view all tweets discussing a particular event, topic, or phenomenon.

Twitter content analysis research has been focused on categorizing both the type of content within tweets and the users tweeting. One of the earliest studies found that the main uses of Twitter were for daily chatter, conversations, sharing information and reporting news (Java et al., 2007). However, this study stipulated that any tweet using an @ sign was facilitating conversations and was coded as such in their research study. This is contested in further research studies because it does not confirm that two-way communication is occurring. Honeycutt & Herring built on this content categorization by specifying that a conversation must consist of both an initiation and response (Honeycutt & Herring, 2009)

In 2010, research on the topic continued and four key categories of Twitter content were outlined (Naaman et al., 2010). These categories included opinions and complaints, information sharing, statements and random thoughts, and "me now" statements. "Me now" statements were the most abundant type of Twitter content, which went back to the original purpose of Twitter where users are answering the question of, "What are you doing now?" (Naaman et al., 2010). Nearly 80% of users are updating their users on what they are currently doing, while the rest are more informational in nature (Naaman et al., 2010).

This research also attempted to outline the types of users on Twitter. Despite this categorization, Twitter users are not limited to a single user type, but rather shift their role throughout the Twitter community largely based on each tweet. Java et al. identified information sources, friends, and information seekers as the three types of users (Java et al., 2007).

Naaman et al. had a differing and more simplistic categorization of Twitter users: "Meformers" and informers. The term "meformers" refers to users posting messages about their lives or personal thoughts while informers are posting informational messages, often such as news or local events (Naaman et al., 2010). However, this divide between Twitters users remains a complicated distinction in an age where fake news runs rampant on social media. It is hard to know whether informers are credible, or whether their information is skewed or incorrect. Particularly when dealing with polarized information, credibility becomes overwhelmingly subjective. Therefore, the categorization system provided by Java et al. may prove more useful for this study that is dealing with the polarized topic of climate change.

It is clear that although Twitter is often used socially as a means to converse and update users of their own lives and current circumstances, it is largely influential as a way to disseminate information quickly (Thelwall, 2011). The opportunity to quickly relay informational updates online has vast potential for event detection, particularly in times of crisis.

Event Detection on Twitter

Social media allows access to unprecedented amounts of real-time data generated by users, which is publicly available amidst times of crisis. Specifically, Twitter can be used to track the well-being of communities during times of crisis to gain a better understanding of the events unfolding, whether it is a pandemic or natural disaster crisis. By having real-time events detected via social media, this could allow for more efficient response and recovery for communities (Broniatowski et al., 2013).

Social media event detection is extremely valuable for understanding natural disasters. One of the major studies illustrating the impact social media event detection can play in disaster recovery was done by Sakaki, Okazaki, and Matsuo in 2010. Their study tracked the location of user tweets in order to detect earthquakes. They classified tweets based on the inclusion of terms “earthquake” and “shaking” in posts. They found that the higher number of users discussing the disaster in a given area lead to a higher estimation accuracy. A serious limitation of Sakaki et al.’s approach to event detection is that it relies on the accurate inclusion of location data associated with a tweet. However, only about 1% of tweets even contain geotag metadata, which are often tagged to the user’s default location as opposed to their current location at the time of a tweet

(Middleton et al., 2014). Additionally, users can change their Twitter location to whatever they want, even if it is not accurate.

Due to these study limitations, Middleton et al. (2014) explored the feasibility to accurately gather a tweet's location data. The system they used preloaded geospatial data into a database. The system then searches for tweets which contain tokens from a set of pre-determined target words, for example "hurricane" or "wildfire." Next, the system attempts to parse the tweet from the location name to determine the location of the event. Depending on whether the location met a specified number of tweets, it would or would not be designated as an event location. When this system was tested during Hurricane Sandy, it was found to have a precision rate greater than 90 percent (Middleton et al., 2014).

This rate of precision highlights the potential of these systems to give precise updates during times of crisis based on user generated data. The implications of this study are significant because it allows responders to act quickly in times of crisis. Responders can see where these events are occurring, and also where they are the most intense or dangerous. These event detection systems can help focus responders based on real data. It is a promising solution to providing disaster and recovery relief efforts in the most efficient way possible. This is especially promising in times where natural disasters are hypothesized to grow in both severity and occurrence due to climate change. However, due to the time and resource limitations as well as the ethical considerations of this research paper, user location data will not be collected.

Phases of Disasters

The phases of a disaster shift over time, which is important to consider when discussing and evaluating disaster preparation and response. There are seven key phases in the disaster lifecycle, which include 1) warning or threat, 2) impact, 3) rescue or heroic, 4) remedy or honeymoon, 5) inventory, 6) disillusionment and 7) reconstruction or recovery (DeWolfe, 2000). Both the experiences and needs of a disaster survivor and the surrounding community shift throughout each phase. In order to best serve survivors, disaster relief efforts should follow the time-based phases of disaster response (DeWolfe, 2000).

The warning or threat phase, more generally called the pre-disaster phases, consists of uncertainty and fear. The amount of warning communities receive is dependent on the type of disaster, but for hurricanes communities usually have several days to prepare (DeWolfe, 2000). It is often characterized by a sense of vulnerability and urgency, as people prepare for the event or evacuate if necessary. If warnings are not taken seriously, people may suffer from guilt if there is severe damage and loss (DeWolfe, 2000).

The impact phase can include a wide range of emotional responses, including shock, relief, panic, or hysteria (DeWolfe, 2000). The greater the intensity of the disaster, the greater the psychosocial effects experienced by survivors. Generally, people in crisis first respond with disbelief or confusion, but then begin to focus on survival and physical safety. This gives way to the rescue or heroic phase following the immediate aftermath of the event. During this phase, first-responders are often being deployed in hopes of rescuing others, promoting safety, and restoring power, which are all priorities (DeWolfe,

2000). Some survivors may experience adrenaline induced rescuing behaviors. However, risk assessment may be impaired and injuries are common when cleaning up damage and rescuing others (DeWolfe, 2000).

The remedy or honeymoon phase occurs in the weeks or months following a disaster. At the beginning of this phase, resources and assistance may be plentiful. Shared suffering and recovery often lead to community bonding, as community members give and receive support with one another (DeWolfe, 2000). This phase is often characterized by a sense of optimism and community support. Unfortunately, this phase leads to the inventory phase. Survivors become exhausted as many of the readily available resources have either dried up or moved on to the next crisis at hand. The sense of optimism experienced in the honeymoon phase begins to fade into exhaustion, fatigue, and discouragement (DeWolfe, 2000).

As time goes on, survivors move into the disillusionment phase. While agencies and volunteers pull out, survivors can feel abandoned and resentful (DeWolfe, 2020). Many survivors began to feel the weight of losses and damages, while noting the gaps in available assistant. Stressors begin to compound and pre-existing conditions are exacerbated, hindering the ability to recover (DeWolfe, 2020). Members of the community who are less impacted or have more means to recover begin to return to normal, which can cause division and hostility within the community (DeWolfe, 2020).

The final phase of a disaster is the reconstruction or recovery phase, which can happen several months or years following a disaster ranging widely based on circumstances. It is characterized by a survivor taking full responsibility for rebuilding and overcoming their own obstacles to recovery. Although, it can be emotionally

exhausting it can mark a time of personal growth and meaning as they begin to define a “new normal” and overcome hardship. Many survivors begin to reimagine their priorities and recognize their personal strengths (DeWolfe, 2000).

Due to the limited timeline of data collection for this research, it is unlikely that each phase of disaster recovery will be observed in the tweets collected. Data will only be collected during the storm, which does not give a full picture of the disaster recovery process, which can take many months or years following an event. However, it is important to include the phases of disaster recovery in the literature review. It can help inform the coding process and allow for exploration of how quickly survivors of Hurricane Isaias move through each phase.

Climate Change and Natural Disasters

Anthropogenic climate change is the scientific theory that human behaviors and greenhouse gas emissions are to blame for the rapidly changing climate, which could lead to severe impacts for climate variability and weather extremes (van Aalst, 2006). Climate change is caused by increasing concentrations of greenhouse gases, which trap heat in the atmosphere. Scientists have observed a stark increase in carbon emissions since the rise of the industrial revolution, which coincides with the increased reliance of humans on fossil fuels. These changes have also been accompanied by changes in agriculture and land use. The atmosphere’s response to the rising greenhouse gas concentration is an increased global temperature (van Aalst, 2006).

It is hypothesized that there is a clear relationship between anthropogenic climate change and extreme weather events. As there is a rise in the global temperature level due to greenhouse gas emissions, this has a direct increase in extreme temperatures. This is

why the term climate change is also referred to as global warming.

Additionally, increased temperatures are projected to increase heavy precipitation events leading to more flooding and landslide events (van Aalst, 2006). This is due to the increase in evaporation allowing for more intense precipitation events. It is hard to link specific weather events to climate change, however, there is a growing consensus among scientists that these events will likely increase in occurrence and severity similarly to those observed by temperature and precipitation (van Aalst, 2006).

Climate change itself is becoming a hot topic for debate in society today, especially as it is receiving more attention from the media, scientists, activists, and policy makers alike (Phillips et al., 2014). Public perception is beginning to change and many people are demanding action to address the implications of climate change around the world as climate strikes and summits are becoming a common call to action. This study will assess whether public perception on Twitter matches those observed in society today, looking specifically at natural disaster events. This research study will seek to fill a gap in the existing literature about Twitter perception of climate change and its relationship to natural disasters.

Research Questions and Key Terms

The purpose of this research study is to explore how people are discussing natural disaster events on Twitter. The study seeks to gain an understanding of whether people are linking isolated natural disaster events to climate change in their tweets, perhaps due to the increasing severity and frequency of these events in recent years. This paper looks specifically at Hurricane Isaias, which was a Category 1 hurricane in the record breaking 2020 Atlantic Hurricane season.

The research questions guiding this study include:

RQ 1: How are Twitter users discussing natural disaster events?

RQ 2: Are Twitter users associating specific events to climate change?

For the purposes of this study, the following key terms will be defined

- Natural disaster: an extreme event occurring naturally within one or more of Earth's systems that involves human social structures, specifically vulnerable populations and infrastructure (Phillips et al. 2015)
- Anthropogenic climate change: also known as global warming; the theory that human induced actions are increasing concentrations of greenhouse gases, which trap the heat in our atmosphere leading to higher global average temperatures (Van Aalst, 2006)

Methodology

This paper is a documentary study using a qualitative content analysis of tweets about Hurricane Isaias. I gathered Tweets about a given natural disaster event, Hurricane Isaias, by pulling a sample of tweets that contained the search words “hurricane” and “isaias”, which were case-insensitive. This was done using the Twitter API (Twitter API Documentation, 2020) for free with an easy-to-use Python library, tweepy (Tweepy Documentation, 2020). However, there are several restrictions in place of how much Twitter data can be collected for free and how the data is sampled, which I will discuss later as a study limitation.

I used a qualitative content analysis approach to code the different categories and themes within the tweet sample. I used this approach to get an understanding of how people are processing the storm events as they carry out in real time, which I could not do any other way given the time and resource constraints of a master’s paper during COVID-19. This approach will also allow me to gain an understanding of how people are communicating with others about the event in real time.

Positionality / Researcher Role

Since this is an individual project, I am responsible for the entirety of the research-- from topic selection, data collection, data analysis, and data interpretation. Based on my own interest and acknowledgment of anthropogenic climate change, I may

have potentially brought in bias to the research study. I personally believe that the occurrence and severity of natural disasters is increasing due to climate change. I am aware this may skew my results if I have misinterpreted people's tweets to perpetuate my own beliefs. I have worked hard to eliminate my own potential bias, which I discuss in the conclusion of this paper.

Sample / Research Participants

My population is all tweets that discussed my chosen natural disaster, Hurricane Isaias, between July 30th and August 5th. The sampling unit for my population is a simple random sample of tweets randomly chosen via the Twitter API that use my specified search terms, "hurricane" and "isaias", case-insensitive.

Due to the availability of Twitter data my data is a simple random sample of tweets, generated by the Twitter API itself. Only a small percentage of random tweets are freely accessible within 7-9 days after being posted in real time. I had little to no control over what tweets were publicly available and pulled for me via the Twitter API. More specifically, because the tweet retrieval is done by the Twitter API, I do not know the percentage of relevant tweets my sample includes or how representative my sample tweets are from the entire population pool. This is a limitation of all studies that rely on the free Twitter API to pull tweets. When I pulled my tweets from the Twitter API, I specified the criteria for my search to include search terms "hurricane" and "isaias" and to restrict the dates of retrieval. I collected 30 randomly sampled tweets for each day spanning between July 30th and August 5th. I collected an equal sample size for each day of the storm's duration so that I could explore the changes in discourse as the storm progressed.

Data Collection Methods

For data collection, I utilized the Python script library, tweepy, to extract the tweets from the Twitter API once I created a developer's account on Twitter for research purposes. I have included the code I ran to collect my data in the appendix. When collecting the data in Python, I wrote my data to a CSV file, which I later exported to Microsoft Excel for data cleaning and data analysis.

The benefit of this study approach is that the data already exists in the public domain. I used tweepy, an open source Python library, to gather the tweets from the Twitter API. It was a straightforward process using simple code to extract Tweets from the API. I had access to both online resources and an advisor familiar with the process to help troubleshoot the data collection.

The main limitation to this data collection method is that the data must be gathered within a limited time frame for free access. The Twitter API only allows for free access to Tweets within 7-9 days after being posted, so I had to collect my data in the week following the event. I also had no control over the random sample gathered other than specifying the search terms and criteria.

Data Analysis Methods

When I pulled tweets based on my search criteria, I only pulled a unique tweet ID, timestamp, and the tweet text itself to preserve the user's privacy and anonymity. Once I had this data written to a CSV file, I chose to import it to a Microsoft Excel file to clean and format it. Cleaning the data was relatively simple. It consisted of changing the format of the date timestamp, removing new line syntax from Python, and ensuring emojis were converted correctly between files. Once the data cleaning was complete, I began the

coding process. I went through the tweet data in several iterations for my coding process, allowing natural themes or groupings to emerge from the tweets based on user sentiment. I annotated each tweet in excel, assigning a theme and often a subtheme for each tweet. I began refining my categorical coding through subsequent iterations until no new themes emerged.

Once the coding process was complete, I calculated the occurrences and percentages of each theme and subtheme out of the total number of tweets analyzed. I created visualizations to show this distribution and how the discourse changed while the storm progressed.

Results

Coding Schema and Descriptions

When coding the tweets, two major broad categories emerged from the data. These were “informational updates” and “informal discourse”. These two categories made up 95% of the 210 tweets collected. In addition to the two major categories, two periphery categories also emerged. The periphery categories are “call for information” and “climate change discourse”. Within the two major categories, the data was further coded into subcategories. This paper will define each main category before breaking them down further into subcategories. Each subcategory will also be defined and example tweets will be given.

Categories

Informational Update

Tweets that were informational in nature got grouped together in the “informational update” category. The biggest issue when coding the data was that there was no source information on who was the author of each tweet. This information was not collected in order to preserve the privacy of each user; however, this made the coding process a bit more subjective. The “informational update” category includes tweets that give informational updates about the status of Hurricane Isaias. They often include links to articles and more information. The tweets sound more authoritative and

objective, likely coming from a news outlet or subject expert. As mentioned previously, the tweet source is not identified so no blanket statement can be made about the true newsworthiness of each tweet in this category. However, other factors such as grammar, links, and the nature of the tweet helped group this category.

Informal Discourse

Tweets that were more informal in nature were grouped together in this category. These tweets were often more anecdotal with less formal grammar. Tweets in this category were more likely to tag other users, giving an impression of informal dialogue rather than formal informative updates. Often, these tweets included rambling thoughts or personal narratives of how the storm has impacted them. Again, since no data was collected about the user tweeting these groupings are subjective, but the tweets are presumed to be from an average Twitter user as opposed to a news outlet or expert source. This was determined by grammar, use of emojis, and other characteristics of the tweets.

Climate Change Discourse

Tweets that discussed the impact of climate change on the severity and occurrence of natural disaster events, particularly Hurricane Isaias, were broken out into a separate category. This decision to make a new category was based on the fact that one of the central research questions of this paper was to explore whether or not Twitter users are associating specific natural disaster events to climate change. In addition, these tweets about climate change seemed to come from both informational outlets as well as general users so they did not holistically fit well into either category. An example tweet included in this category is below:

> 'Make no mistake, climate change is impacting #Isaias. Not in a good way either...https://t.co/TmXejmZUjx'

Call for Information

Tweets that asked users for information regarding Hurricane Isaias were grouped in the ‘call for information’ category. Despite being a relatively small category, it was a necessary periphery category because it did not fit well into either ‘informational update’ or ‘informal discourse’. These tweets often seemed to come from news outlets seeking more detailed information about the storm or photos of damage to report on. They were generally coming from informational sources; however, they did not contain formal information themselves. An example tweet included in this category is below:

> 'HURRICANE DAMAGE: Hurricane Isaias left behind flooding and debris after striking the North Carolina coast. Do you have any photos of the damage? https://t.co/IXJjgkmQpz https://t.co/Uze6ZBotsK'

Subcategories

Informational Update

Storm Status

This subcategory includes any informational updates regarding the status of the storm. This was by far the most prominent subcategory of tweets, comprising 44% of all tweets collected. These tweets provided a formal update on the storm status throughout its path, and often included links to more information. Since there was no information collected on the author of each tweet, characteristics such as language, grammar, use of statistics, use of citations, and links to further information deemed these tweets to be informational updates from a news or expert source rather than anecdotal updates tweeted

by any user living through storm conditions. These tweets were more factual in nature about the storm status.

Within this subcategory, three main groupings emerged of different aspects of the storm status being reported. These were: strength, conditions, and track. ‘Strength’ tweets referred to updates on the categorization of storm Isaias based on the Saffir-Simpson scale in particular (i.e. tropical storm, category one, category two, etc.), which varied considerably throughout its time as a named storm. ‘Condition’ tweets gave updates on the conditions accompanying the storm, such as storm surges, precipitation, tides, and wind. ‘Track’ tweets referred to updates on the trajectory and path the storm was projected to take or currently taking. These groupings were considered and coded as a sub-subcategory in storm status, but they ultimately didn’t become subcategories themselves because of the overlap in many tweets. Many ‘storm status’ tweets included two or more of these groupings, so the subcategory was not broken out further. However, it was important to explore these distributions and a table and figure illustrating the distribution of ‘storm status’ tweets will be included in the results section. An example tweet included in the ‘storm status’ subcategory (track sub-subcategory) is below:

> 'Hurricane Isaias is moving northwest through the Bahamas, and will pose a threat to the US and even local areas starting this weekend. Tracking it all on @NBC10! https://t.co/Cbp0THeEk8'

Post-storm Update

This subcategory includes informational tweets about storm damage and any other related updates on conditions, specifically after the storm has hit. These tweets included updates on storm damage, such as property damage. This subcategory also includes any reports on potentially long-lasting impacts on the affected communities, such as loss of

life and displacement. An example tweet included in the ‘post-storm update’ category is below:

> 'At least six people were killed as Tropical Storm Isaias spawned tornadoes and dumped rain Tuesday along the U.S. East Coast after making landfall as a hurricane in North Carolina, where it caused floods and fires that displaced dozens of people. https://t.co/XyowIA7VRs’

Emergency Preparation

This subcategory includes any formal tweets disseminating disaster preparedness information. These tweets include both locally relevant disaster plans and more general guidelines for emergency preparation. The tweets often link out to organizations or links with more information. An example tweet included in the ‘emergency preparation’ subcategory is below:

> ‘We are continuing to monitor weather conditions related to Hurricane Isaias. Now is a great time to review the Hurricane Evacuation Guide from @VDEM, and don't forget to sign up to receive local emergency alert information at https://t.co/Ow2U8GZsR8.’

Closures

This subcategory includes any informational tweets about closures due to the storm. These tweets ranged from local foodbanks to public beaches that used Twitter to disseminate their closure updates to their followers and to the general public. Despite no tweet data, each tweet seemed to come from an official or spokesperson within an organization or city. These tweets were generally formal with proper grammar, and included specific details on closures. An example tweet included in the ‘closures’ subcategory is below:

> 'Due to Hurricane Isaias, City of Vero Beach parks and beaches will close Saturday, August 1st at 5:00 p.m. and open Sunday, August 2nd at 12 noon. Lifeguards will not be on duty and restrooms will be closed during those hours.'

Emergency Response

This subcategory includes any information on emergency response efforts following the storm. These tweets seemed to come from either news outlets trying to spread information or by official organizations that aid with emergency response themselves. These tweets occurred either during or shortly following the storm. An example tweet included in the 'emergency response' subcategory is below:

> 'Here's what we've been doing so far to help those displaced by #Isaias in Southeastern Pennsylvania: https://t.co/XrQbGU9hXq
> Anyone who needs our help should call 1-800-RED-CROSS'

News Cycle

This subcategory included tweets that mentioned the storm within a headline of current news event, however did not relay much factual information within the tweet itself. Despite seemingly coming from a reputable source, these tweets simply listed off the big current headlines before linking out to another page for more information. Since no substantial storm update is given within these 'news cycle' tweets, this subcategory was broken out into a new one. An example tweet included in the 'news cycle' subcategory is below:

> 'Before you go: 1,346 new cases of coronavirus; Hurricane Isaias may impact Charleston; Census may be cut short experts worried about undercount https://t.co/2AXjJOcP11'

<u>Informal Discourse</u>

Personal Thoughts

This subcategory was used to group personal reflections about the storm and general updates. Tweets in this group were often very informal and acted as a sort of information processing for the user of the events taking place, resembling "me now"

tweets discussed in the literature review. As opposed to the subcategory ‘storm update’, the tweets in this subcategory discuss the storm in more general terms while focusing more on processing the events while often considering other various things happening in their lives. This is different from the ‘storm update’ subcategory, which was categorized by more specific details of storm conditions by someone presumably living through it in real time. An example tweet included in the ‘personal thoughts’ subcategory is below:

> 'Isaias Set to Brush Florida With Wind and Rain. Yay! Good news! I guess I can dig into my hurricane party treats early then, eh? However, my pup is still hunkered down under the coffee table, keeping an eye out on the plants that were brought in! 😂🐊💕'

Comedy

This subcategory included any informal tweets that had a comedic element. Tweets in this group often seemed to use comedy or meme culture to react to the storm and its consequences with humor. It was difficult to code this category because comedy is very subjective between each person. Several tweets also seemed to use sarcasm, which is hard to understand without context or body language. An example tweet included in the ‘comedy’ subcategory is below:

> 'Is it just me or does the name of this new hurricane sound like something Harry Potter/Voldemort would say in Parseltongue? #Isaias'

Dialogue

This subcategory included any informal tweets between users. Specifically, it included tweets that tagged other users. This included tweets that appeared to reply to an initial post or call out a user by tagging them throughout the tweet. These tweets seemed to be generally conversational between users that were centered around Hurricane Isaias.

However, these are distinct from the ‘support & prayers’ subcategory, which was specifically for well-wishing and support to those negatively affected by the storm. An example tweet included in the ‘dialogue’ subcategory is below:

> ‘@AdamJanikUF Yeah, but at least Sandy was a pretty significant hurricane at one point and it also merged with another storm. Isaias was basically just a TS. If they can't handle that then man they have some work to do’

Storm Damage

This subcategory includes any informal tweets that describe damages from Hurricane Isaias. This includes informal updates on things such as property damage, power outages, and wildlife habitat damage. These tweets describe more personal damages experienced, often including emotions in the response, as opposed to a news outlet source reporting storm damage statistics and headlines. An example tweet included in the ‘storm damage’ subcategory is below:

> ‘SO SAD: Last night's high tide and storm surge wreaked havoc on a sea turtle nest in Cherry Grove. 🐢’

Storm Update

This subcategory includes any tweets describing conditions of the storm. It gives updates on the current state of the storm, presumably by someone experiencing it in real time. These tweets provide storm condition updates, but differ from ‘informational updates’ because they are more descriptive and informal as opposed to a news broadcast. Generally, the grammar is more casual and links to more information are not included. However, there are often photos or videos attached, presumably taken by the user themself. An example tweet included in the ‘storm update’ subcategory is below:

> ‘That's him...Isaias. The surge must be several feet😱 #HurricaneIsaias2020 #HurricaneIsaias #ISAIAS @DFB_City #hurricane #Florida #FloridaWeather (video attached)’

Support & Prayers

This subcategory includes tweets by users that are wishing well to those affected by the storm. These tweets express genuine support by offering prayers and words of support to those affected. An example tweet included in the 'support & prayers' subcategory is below:

> 'GOD IS IN CONTROL! PRAYERS FOR EVERYONE THAT IS GOING THROUGH HURRICANE ISAiAS INCLUDING MY FAMILY. MAY THE LORD COVER AND KEEP YOU PROTECT YOU AND SHINE HIS GRACE UPON YOU. I SPEAK PEACE...'

Political

This subcategory includes any tweets that engage in political discourse. This includes commentary on political leaders and how the government responds and prepares for this emergency, as well as the ongoing pandemic, COVID-19. These tweets are often informal and expressing the user's own opinions of the political response to Hurricane Isaias. An example tweet included in the 'political discourse' subcategory is below:

> 'Liberal rag wrong again. Like their COVID numbers.. Hurricane warning lifted as Tropical Storm Isaias weakens - South Florida Sun-Sentinel https://t.co/c66h5MQtXa'

Distribution of Coding Categories

The results of the content analysis are outlined below in various tables and figures below. Results are broken down by each category, subcategory, and storm status type. Each table includes total occurrences and percentage values (Tables 1, 2, 3, and 4). Results are further broken down into figures to show distribution of category and

subcategories for each day of data collection (Figures 2, 3, and 4). A timeline of Hurricane Isaias is also included to provide context for daily tweet distribution (Figure 1).

Table 1 shows the tweet distribution by each major category. The four main categories that emerged from the data were ‘informational update’, ‘informal discourse’, ‘climate change discourse’, and ‘call for information’. This table includes the total number of tweet occurrences for each category and the percentage that category makes up of all tweets collected. ‘Informational update’ tweets accounted for over half of all tweets, and ‘informal discourse’ was the second largest category accounting for nearly a third of all tweets. It is important to mention that tweets referring to climate change were a small percentage of total tweets, but still a substantial 2.9% of all tweets. When given the small sample size of the tweets collected and the broad search query for data collection, this is a significant finding for answering RQ 2.

Table 1: Tweet Distribution by Category

Category	**Total Occurrences**	**Percentage of Tweets**
Informational Update	134	63.8%
Informal Discourse	66	31.4%
Climate Change Discourse	6	2.9%
Call for Information	4	1.9%

Table 2 shows the tweet distribution of each subcategory within the ‘informational update’ category. This table shows the total number of tweet occurrences for each subcategory and the percentage of tweets each subcategory makes up out of the broader category. It also shows the percentage of tweets each subcategory makes up out of all the tweets collected. The ‘storm status’ category made up an overwhelming majority of all tweets in this subcategory, which included providing informational

updates on the strength, conditions, and track of the storm. ‘Post-storm update’ tweets and ‘emergency preparation’ tweets were the next biggest subcategories with approximately 10% each. This was followed by ‘closures’, ‘emergency response’ and ‘news cycle’, which each accounted for approximately 2-4% of the tweets in the subcategory.

Table 2: Tweet Distribution by Informational Update Subcategories

Informational Update Subcategory	**Total Occurrences**	**Percentage of Category**	**Percentage of Tweets**
Storm Status	93	69.4%	44.3%
Post-storm Update	15	11.2%	7.1%
Emergency Preparation	14	10.4%	6.6%
Closures	6	4.5%	2.9%
Emergency Response	3	2.2%	1.4%
News Cycle	3	2.2%	1.4%

Table 3 shows the tweet distribution of each subcategory within the ‘informal discourse’ category. This table shows the total number of tweet occurrences for each subcategory and the percentage of tweets each subcategory makes up out of the broader category. It also shows the percentage of tweets each subcategory makes up out of all the tweets collected. The ‘personal thoughts’ subcategory was the largest, with nearly one third of all the category tweets. ‘Comedy’ contained nearly one fourth of the category tweets. ‘Storm damage’ and ‘storm update’ both accounted for roughly 10% of this category. ‘Support & prayers’ and ‘political’ tweets each accounted for 6% of the category, as well. It is interesting to note that even the largest subcategory within ‘informal discourse’ made up only 10% of all tweets collected. This is much lower than the largest subcategory for ‘informational updates’ category.

Table 3: Tweet Distribution by Informal Discourse Subcategories

Informal Discourse Subcategory	**Total Occurrences**	**Percentage of Category**	**Percentage of Tweets**
Personal Thoughts	21	31.8%	10%
Comedy	15	22.7%	7.1%
Dialogue	9	13.6%	4.3%
Storm Damage	7	10.6%	3.3%
Storm Update	6	9.1%	2.9%
Support & Prayers	4	6.1%	1.9%
Political	4	6.1%	1.9%

Table 4 shows the tweet distribution of the 'storm status' subcategory, which was further broken down into types: strength, conditions, and track. The decision to break down the 'storm status' subcategory further for exploration was due to the vast majority of tweets it contained (69% of the 'informational update' category and 44% of all tweets). However, each storm status type did not become a new subcategory itself because most tweets contained two or more types of status update. This is illustrated in the table below, which breaks down storm status type into total tweet occurrences, percentage of the subcategory, and percentage of all tweets. Nearly 40% of 'storm status' tweets discussed two or more types, followed by tracking with 22%, strength with 21%, and conditions with 16%.

Table 4: Tweet Distribution by Storm Status Type

Storm Status	**Total Occurrences**	**Percentage of Subcategory**	**Percentage of Tweets**
2 or more	37	39.8%	17.6%
Tracking	21	22.6%	10%
Strength	20	21.5%	9.5%
Conditions	15	16.1%	7.1%

Figure 1 is a simplified timeline of events following the formation and categorization of Hurricane Isaias. It provides information on the storm's varied strength

and track throughout its time of formation until it was re-classified as a post-tropical cyclone on August 5th. It also includes a coinciding timeline of Twitter data collection for this research paper. This figure helps provide context on the storm before breaking down tweet distribution by each day of the storm.

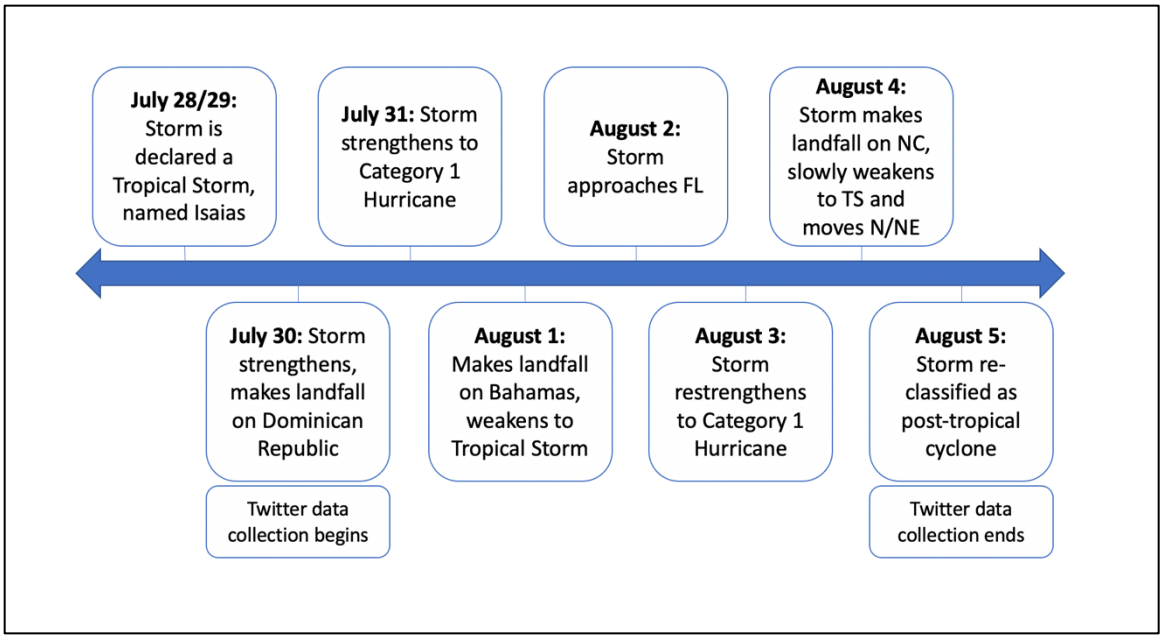

Figure 1: Timeline of Hurricane Isaias and Data Collection

Figure 2 illustrates the daily change in tweet count distribution by category for each day of data collection. 'Informational update' tweets make up a majority of the tweet counts from July 30th-August 3rd, but once Isaias makes landfall in NC and begins to weaken, 'informational update' tweet counts decrease rapidly. At this same time, 'informal discourse' and 'climate change discourse' tweets begin to increase as the storm weakens and gets re-classified as a post-tropical cyclone moving north. 'Call for information' tweets remain relatively low throughout the storm, but peak on the day the storm makes landfall in NC.

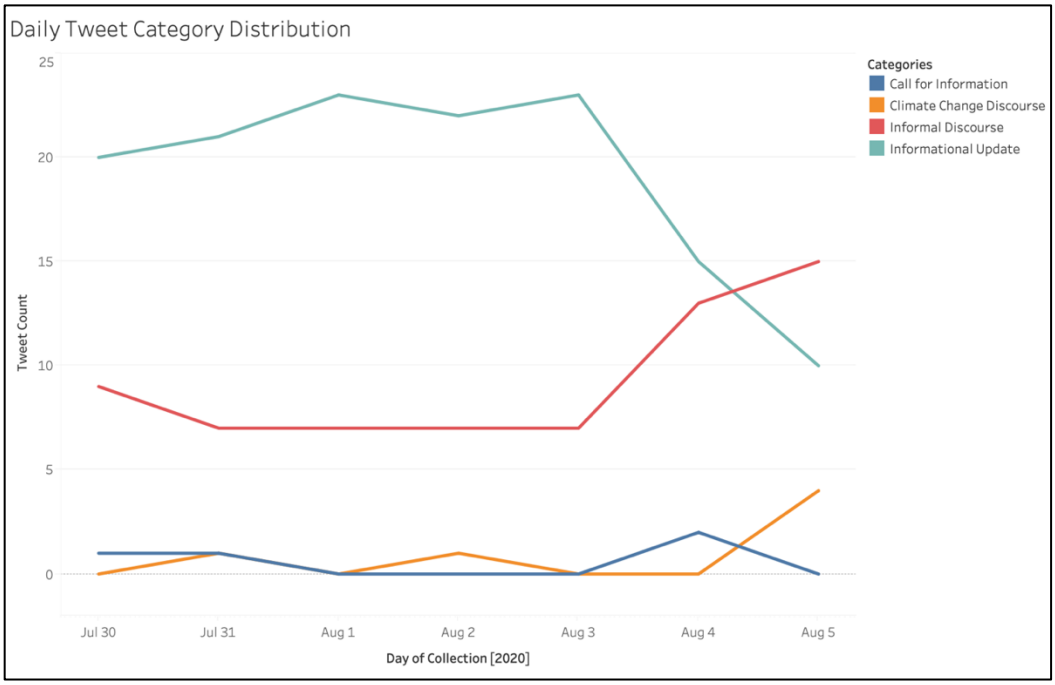

Figure 2: Daily Tweet Distribution by Category

Figure 3 illustrates the daily changes in 'informational update' tweet count distribution by subcategory for each day of data collection. ‘Storm status’ tweets make up a vast majority of this category’s tweets until August 4th, when Isaias makes landfall and weakens. ‘Emergency preparation’ tweets remain relatively consistent until August 5th, when the storm weakens and is re-classified. ‘Closures’ and ‘news cycle’ tweets only appear in the first 2-3 days of the storm, as the storm is developing and likely making headlines. Once the storm makes landfall and begins to weaken, ‘post-storm updates’ and ‘emergency response’ tweets begin to occur, starting August 3rd.

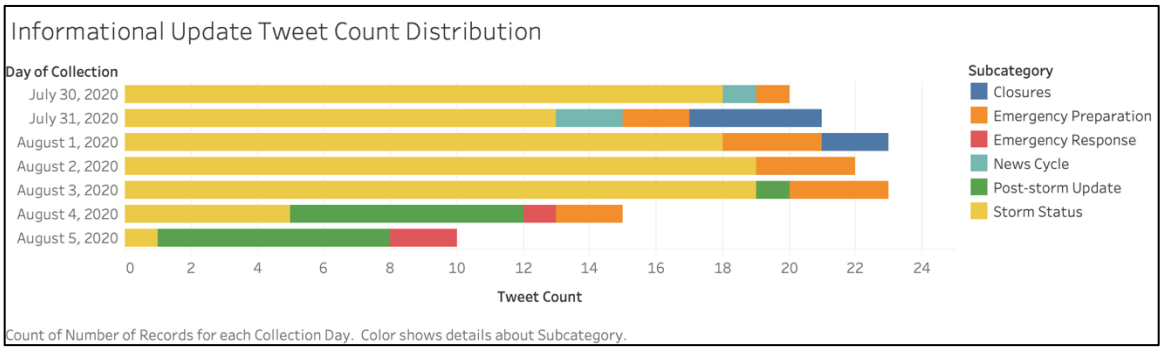

Figure 3: Daily Tweet Distribution by Informational Update Subcategory

Figure 4 illustrates the daily changes in 'informal discourse' tweet count distribution by subcategory for each day of data collection. The first thing to note is that total tweet count per day remains relatively constant until it increases on August 4th, when Isaias makes landfall in NC and begins to weaken. There are less apparent trends in this subcategory dataset, likely due to the increased number subcategories and informality of the category itself. 'Personal thoughts' and 'comedy' tweets are prominent throughout each day of the storm. 'Storm updates', 'storm damage', and 'dialogue' all increase around August 3rd-5th. 'Support & prayers' tweets are concentrated during the first and last days of data collection. There seems to be no clear trend of the 'political' subcategory distribution.

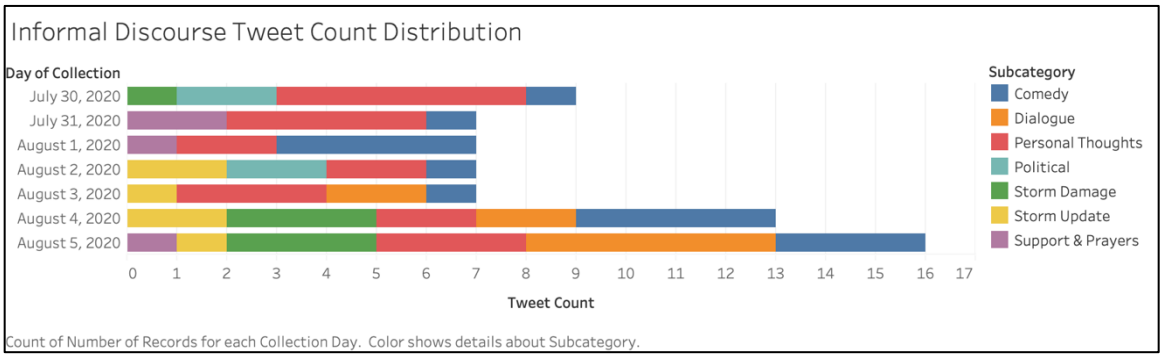

Figure 4: Daily Tweet Distribution by Informal Discourse Subcategory

Figure 5 illustrates the daily changes in the 'storm status' distribution of tweet type (strength, condition, tracking) for each day of data collection. It is important to note that unlike in Table 4, these are total daily counts. If a tweet discussed multiple 'storm status' type updates, then it was added to both tweet counts for each type. 'Strength' and 'tracking' were more prominent than 'condition' tweets. On August 4th, all three types decreased significantly as the storm weakened. Interestingly, the day Isaias restrengthens to a category 1 hurricane is the day with the highest count of 'strengthen' tweets.

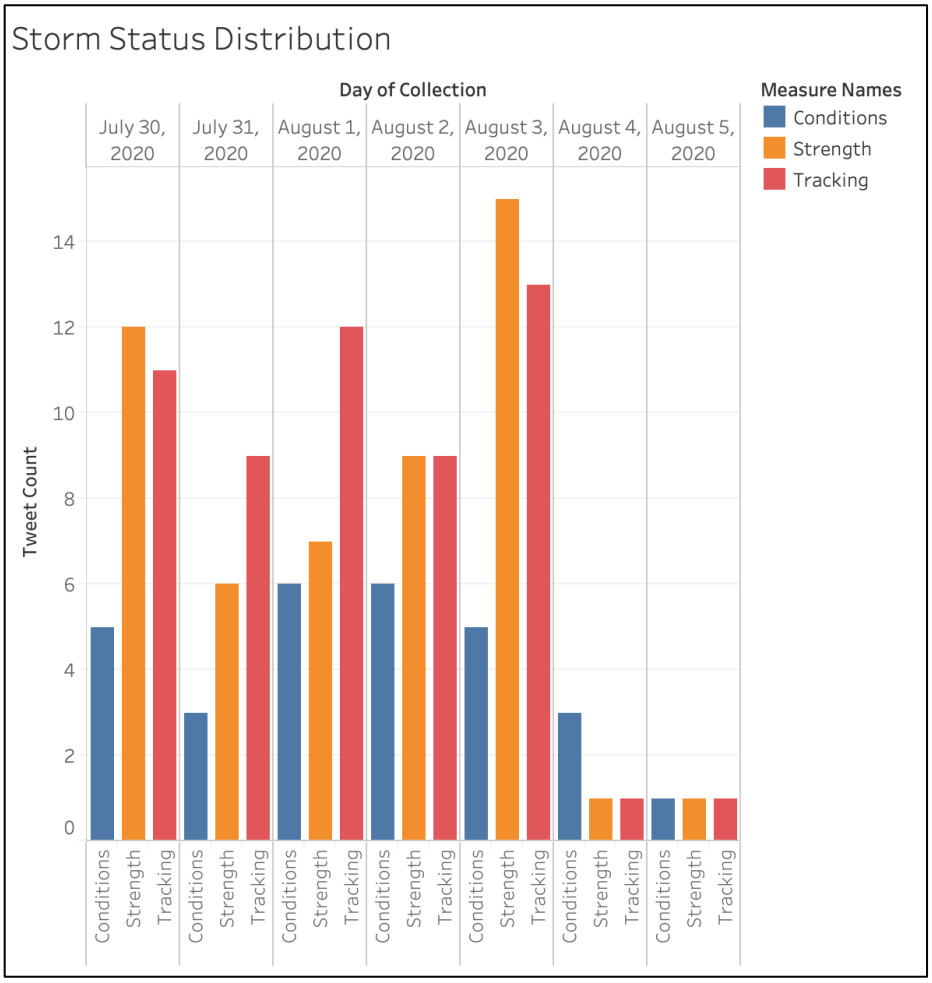

Figure 5: Daily Tweet Distribution by Status Type

Discussion

Based on the results of this paper, it is clear that 'informational updates' on Twitter dominated the public discourse of Hurricane Isaias as the storm was developing and approaching landfall (July 30th-August 3rd). User's need up-to-date information as the storm approaches so that they are able to prepare for the storm safely and evacuate if necessary. It is reassuring to know that a vast majority of all tweets leading up to the storm provided users with this necessary information.

After the storm made landfall in North Carolina, it experienced quick weakening as it moved northeast. When collecting data on August 4th and August 5th, this weakening seems to be reflected in the online discourse and distribution of tweets. Instead of a majority of tweets providing 'informational updates', users engaged in more 'informal discourse', allowing them to give "me-now" updates and recount their storm experiences. News headlines move quickly, particularly in a year as eventful as 2020, so it is not surprising that the tweets quickly shift from 'informational updates' to this more 'informal discourse' once the worst part of the storm is over. The finding that 'informal discourse' accounts for less tweets earlier on may be explained by the fact that until users have experienced the storm themselves, they can't provide as many anecdotal updates about the experience.

The 'informational update' subcategory distribution seemed to coincide with the timeline of the storm. 'Storm status' updates made up the majority of 'informational updates' until August 4th and 5th. 'Storm status' updates provided users updated

information on the storm strength, conditions, and projected track. This is crucial information so the public knows both who the storm will impact and how severely. It is no surprise that once the storm started to weaken after making landfall, these updates were less crucial to the safety of users and began to decrease. 'Emergency preparation' tweets made up a consistent portion of tweets daily, until August 5th when the storm was re-classified as post-tropical. In total, 'emergency preparation' tweets accounted for over 10% of the 'informational update' category and nearly 7% of all tweets. It is important that users are able to find emergency preparation resources and information via Twitter throughout the storm, particularly as the projected track changes and begins to effect new locations and people. It would be interesting to see whether the percentage of 'emergency preparation' tweets increased for a more dangerous storm above Category 1. The more dangerous the storm, the more important it is for users to access emergency preparation resources. This could be a question for potential further studies on this topic, which could add to these findings.

During the beginning of the storm, 'closures' and 'news cycle' tweets accounted for a small portion of 'informational update' tweets before they stopped occurring after August 1st. It is not surprising that the first day the storm develops, it is mentioned in news headlines. The results show that as the storm is developing and approaching, closures are being announced. Once the storm has hit, it is likely that closures are no longer taking place, which would account for the decrease in 'closure' tweets altogether. Once the storm makes landfall in North Carolina, two new subcategories emerge from the data. These are 'post-storm updates' and 'emergency response'. Naturally, neither

subcategory could exist before the storm makes landfall because both are providing updates about post-storm conditions.

When breaking down the types of 'storm status' updates given by day, there are a few significant findings. The first is that the 'strength' update reached its highest count on August 3rd, when Hurricane Isaias was re-classified as a category 1 hurricane. The second finding is that 'strength' and 'track' updates were most prominent every day in comparison to 'condition' updates. This may be because it is most important to know who will be affected and how significantly, as opposed to informing users on the specific conditions that may be encountered. Lastly, all 'storm status' update types decrease significantly once the storm makes landfall and weakens.

The 'informal discourse' daily distribution remained consistent until August 4th and 5th when it nearly doubled. This is likely attributed to the weakening of the storm, when breaking updates are no longer crucial to discourse. At this point, users had more time to share personal thoughts and recount their own experiences during the storm. 'Personal thoughts' and 'comedy' were the most prominent subcategories and their distribution was consistent throughout each day of the storm. This could be attributed to the broadness of each subcategory. The occurrence of 'comedy' tweets may also show that people are likely to cope with intense or traumatic experiences using comedy. It also may be influenced by the meme culture dominant on social media these days. Many people use memes and comedy to combat anxiety or stressful events.

After the storm makes landfall and begins to weaken, 'storm updates', 'storm damage', and 'dialogue' all increase in tweet distribution. As more users have experienced the storm, they appear to take to Twitter to discuss and process the event.

The increase in ‘dialogue’ tweets may show that users are yearning for a sense of community and collectiveness after experiencing a traumatic event. Interestingly, the ‘support & prayers’ category is most prominent on the first and last days of the storm. Based on the distribution, it appears that once users first hear about the storm development, they want to wish others in the path well and again once they see some of the damage from the storm.

It is important to note that although this discussion offers some potential explanations of tweet distributions, it is largely speculation based on comparing the results to the given context of the storm timeline. Content analysis is limited in that it can only provide findings that increase understanding of how content is being discussed and categorized, but it does not explain why. This research paper does not seek to explain the ‘why’, but some potential factors are considered in the discussion to potentially prompt further research.

Based on the results of this paper 2.9% of the tweets in the sample discussed climate change as having a potential impact in the formation and strength of Hurricane Isaias. That is a total of six out of the 210 tweets collected discussing climate change explicitly in regards to this storm. Although this is a low percentage, it is certainly significant when compared to the fact the ‘informational update’ subcategory on closures accounted for the same percentage of total tweets. These ‘climate change discourse’ tweets seemed to come from both average users and informational resources. Four of the tweets referenced external links and articles from reputable sources, including a New York Times article and a scientific community blog. These findings may signify a shift in public perception that climate change is in fact affecting these natural disaster events.

Conclusion

It is important to see how people are using Twitter throughout natural disaster events because it is a way to gather and disseminate critical information in times of crisis. This research study begins to gain an understanding of how people are discussing and processing natural disaster events in real time online, which could help disaster relief and recovery become more efficient. It is also important to know that a percentage of Twitter users are drawing connections between natural disaster events and climate change. This is useful information for policy makers and climate activists, alike, to push for making changes to climate policy, hazard prevention, and mitigation efforts.

A clear limitation of this study is the difficulty in gathering a specialized sample of Twitter data within the given timeline of the freely accessible Twitter API. The study's sample is random, but it is unknown exactly how the data was collected via the API. This may affect the data quality and thus the results determined from the study.

Another limitation is that a content analysis does not answer the "why" question of research. Although there are significant findings of "how" users are discussing Hurricane Isaias, this study is unable to understand why users feel or act in a certain way. This is even more true for a content analysis of tweets because of the limited 140-character count. There is significant room for misinterpretation of a tweet with little to no context, particularly while trying to preserve the privacy of each user. Since the Twitter data is treated anonymously and there are not study participants to interact with, no clarification or reasoning for any of the tweet's meaning can be gathered.

Despite the possible limitations, this research study is one that will add and expand the current literature about public discourse via Twitter, particularly during natural disasters. It can help researchers and policymakers gain a better understanding of how users associate natural disasters to climate change. In addition, it could help policy makers and local governments engage with users via Twitter to disseminate critical disaster relief and recovery information, increasing information resources available to users during emergencies and helping them feel empowered.

References

André, P., Bernstein, M., & Luther, K. (2012). Who gives a tweet?: Evaluating microblog content value. Paper presented at the Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work, 471-474.

Broniatowski, D. A., Paul, M. J., & Dredze, M. (2013). National and local influenza surveillance through Twitter: an analysis of the 2012-2013 influenza epidemic. *Plos One*, *8*(12).

Büchi, M. (2017). Microblogging as an extension of science reporting. *Public Understanding of Science (Bristol, England)*, *26*(8), 953–968.

Chew, C., & Eysenbach, G. (2010). Pandemics in the age of Twitter: content analysis of Tweets during the 2009 H1N1 outbreak. *Plos One*, *5*(11).

Dewolfe, D. (2000). Training manual for mental health and human service workers in major disasters. *Department of Health and Human Services.* Retrieved November 4, 2020 from https://www.hsdl.org/?view&did=4017.

García-Ramírez, G. M., Bogen, K. W., Rodríguez-Guzmán, V. M., Nugent, N., & Orchowski, L. M. (2020). #4645Boricuas: Twitter reactions to the estimates of deaths by Hurricane María in Puerto Rico. *Journal of Community Psychology*.

Honeycutt, C., & Herring, S. C. (2009). Beyond microblogging: Conversation and collaboration via Twitter. Paper presented at the 42nd Hawaii International Conference on System Sciences, 1-10.

Java, A., Song, X., Finin, T., & Tseng, B. (2007). Why we twitter. In *Proceedings of the 9th WebKDD and 1st SNA-KDD 2007 workshop on Web mining and social network analysis - WebKDD/SNA-KDD '07* (pp. 56–65). New York, New York, USA: ACM Press.

Kirilenko, A. P., Molodtsova, T., & Stepchenkova, S. O. (2015). People as sensors: Mass media and local temperature influence climate change discussion on Twitter. *Global Environmental Change*, *30*, 92–100.

Middleton, S. E., Middleton, L., & Modafferi, S. (2014). Real-Time Crisis Mapping of Natural Disasters Using Social Media. *IEEE Intelligent Systems*, *29*(2), 9–17.

Naaman, M., Boase, J., & Lai, C. H. (2010). Is it really about me?: Message content in social awareness streams. Paper presented at the Proceedings of the 2010 ACM Conference on Computer Supported Cooperative Work, 189-192.

Nishikawa, S., Tanaka, N., Utsu, K., & Uchida, O. (2018). Time trend analysis of "#rescue" tweets during and after the 2017 northern kyushu heavy rain disaster. In *2018 5th International Conference on Information and Communication Technologies for Disaster Management (ICT-DM)* (pp. 1–4). IEEE.

Pearce, W., Holmberg, K., Hellsten, I., & Nerlich, B. (2014). Climate change on Twitter: topics, communities and conversations about the 2013 IPCC Working Group 1 report. *Plos One*, *9*(4).

Phillips, M. C. K., Cinderich, A. B., Burrell, J. L., Ruper, J. L., Will, R. G., & Sheridan, S. C. (2015). The effect of climate change on natural disasters: A college student perspective. *Weather, Climate, and Society*, *7*(1), 60–68.

Pohl, D., Bouchachia, A., & Hellwagner, H. (2012). Automatic sub-event detection in emergency management using social media. In *Proceedings of the 21st international conference companion on World Wide Web - WWW '12 Companion* (p. 683). New York, New York, USA: ACM Press.

Sakaki, T., Okazaki, M., & Matsuo, Y. (2010). Earthquake shakes Twitter users: Real-time event detection by social sensors. In *Proceedings of the 19th international conference on World wide web - WWW '10* (p. 851). New York, New York, USA: ACM Press.

Thelwall, M. (2011). Sentiment in twitter events. *Journal of the American Society for Information Science and Technology*, 62(2), 406-418. .doi:10.1002/asi.21462

Thompson, A. (2020, October 09). A Running List of Record-Breaking Natural Disasters in 2020. Retrieved November 08, 2020, from https://www.scientificamerican.com/article/a-running-list-of-record-breaking-natural-disasters-in-2020/

Tweepy Documentation (2020). Retrieved June 20, 2020 from http://docs.tweepy.org/en/latest/.

Twitter API Documentation (2020). Retrieved June 20, 2020 from https://developer.twitter.com/en/docs/twitter-api.

van Aalst, M. K. (2006). The impacts of climate change on the risk of natural disasters. *Disasters*, *30*(1), 5–18.

Veltri, G. A., & Atanasova, D. (2017). Climate change on Twitter: Content, media ecology and information sharing behaviour. *Public Understanding of Science (Bristol, England)*, *26*(6), 721–737.

Zhou, X., & Chen, L. (2014). Event detection over twitter social media streams. *The VLDB Journal*, *23*(3), 381–400.